Simulating the Cranfield geological carbon sequestration project with high-resolution static models and an accurate equation of state

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Abstract

A field-scale carbon dioxide (CO_2) injection pilot project was conducted as part of the Southeast Regional Sequestration Partnership (SECARB) at Cranfield, Mississippi. We present higher-order finite element simulations of the compositional two-phase CO_2-brine flow and transport during the experiment. High-resolution static models of the formation geology in the Detailed Area Study (DAS) located below the oil-water contact (brine saturated) are used to capture the impact of connected flow paths on breakthrough times in two observation wells. Phase behavior is described by the cubic-plus-association (CPA) equation of state, which takes into account the polar nature of water molecules. Parameter studies are performed to investigate the importance of Fickian diffusion, permeability heterogeneity, relative permeabilities, and capillarity. Simulation results for the pressure response in the injection well and the CO_2 breakthrough times at the observation wells show good agreement with the field data. For the high injection rates and short duration of the experiment, diffusion is relatively unimportant (high Péclet numbers), while relative permeabilities have a profound impact on the pressure response. High-permeability pathways, created by fluvial deposits, strongly affect the CO_2 transport and highlight the importance of properly characterizing the formation heterogeneity in future carbon sequestration projects.